

The Combination of Hydrogen and Oxygen in Contact with Hot Surfaces.

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(Abstract.)

The authors have made a systematic investigation of the slow combination of hydrogen and oxygen in contact with various heated surfaces, including porous porcelain, magnesia, metals such as gold, silver, platinum and nickel, and reducible oxides such as ferric oxide, nickel oxide, and copper oxide.

In each case the moist gaseous mixture was circulated at a uniform speed over the surface, which was maintained at a constant temperature in the combustion tube of the "circulation apparatus" employed by the authors in their researches on the slow combustion of hydrocarbons.

Since the steam produced was rapidly removed by condensation from the sphere of action, the rate of combination was measured by observing the pressure fall in the apparatus during successive time intervals.

The results prove conclusively that in no case does the rate of combination depend on the "order" of the reaction, as was asserted some years ago by Bodenstein* (in the case of porous porcelain), nor yet is it governed by diffusion factors, as suggested by Nernst.† Equally certain, also, is it that the process cannot be explained by any purely chemical theory, such, for example, as the view that it involves a rapidly alternating series of oxidations and reductions of the catalysing material.

The catalysing power of a new surface usually increases up to a steady maximum when successive charges of electrolytic gas are circulated over it, and after the attainment of this steady state, the rate of combination for normal electrolytic gas is always directly proportional to the pressure. That is to say, the velocity curve for electrolytic gas is always of a "monomolecular" type.

When one or other of the reacting gases is present in excess, the rate of combination is nearly proportional to the partial pressure of the hydrogen. This applies to all the surfaces examined, except silver and copper oxide. In the case of silver, the rate is proportional to the partial pressure of the hydrogen up to a certain condition of maximum "hydrogenation" of the surface, after which it is governed largely by the oxygen pressure. In

* 'Zeit. Phys. Chem.,' vol. 29, p. 665, 1899.

† 'Zeit. Phys. Chem.,' vol. 47, p. 52, 1904.

the case of copper oxide, the rate of combination depends mainly on the partial pressure of the oxygen.

The catalysing power of porcelain, magnesia, and the metallic surfaces examined, can be stimulated, often in a high degree, by previous exposure to hydrogen at moderately high temperatures, and all these surfaces have the power of occluding hydrogen at dull red heat.

The results of the research as a whole prove that, except in the case of copper oxide, hydrogen plays an all important rôle in the catalytic process, being rendered "active" by association with the surface. In the majority of cases the hydrogen is merely "occluded" or "condensed" by the surface, but in the case of silver, there is evidence of a more intimate association, such as the formation of an unstable hydride at the surface.

In the case of copper oxide, the catalytic process depends primarily on the condensation of a film of "active" oxygen on the surface; so far from the surface taking any *direct* part in the formation of steam, it is actually protected by the film of condensed oxygen from the attacks of the hydrogen, which would otherwise energetically reduce it.
